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SLEEP PATTERNS OF NAVAL AVIATION PERSONNEL CONDUCTING MINE HUNTING OPERATIONS

by

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September 2006

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Detailed research conducted over the past forty years has conclusively determined that varying degrees of sleep loss, shifts in sleep cycle, increased stress and even changes in time zone with respect to daylight transition result in a myriad of physiological and psychological degradations (Helmreich, 2000). Fatigue affects human performance, resulting in predictable changes not only on the individual level but also on the system as a whole.

This descriptive study investigates the amount and quality of sleep received by aviation personnel assigned to an operational squadron conducting mine hunting operations. Wrist activity monitors (actigraphs) were used to determine objective assessments of sleep quantity and quantity. Demographic variables and additional measures such as reported sleepiness, fatigue ratings, caffeine and alcohol use, were also collected. Despite a number of factors which altered the original study design, significant differences in amount of sleep, sleep quality and predicted effectiveness of personnel by officer-enlisted status were identified.

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SLEEP PATTERNS OF NAVAL AVIATION PERSONNEL CONDUCTING MINE HUNTING OPERATIONS

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EXECUTIVE SUMMARY

The aviation environment is challenging and unforgiving, requiring aircrew and maintenance personnel to maintain a high degree of vigilance. As Helmreich and Davies (2004) demonstrated, fatigue can result in diminished mental capacity, slowed reaction time, increased spatial disorientation, propensity for miscommunication, sensory misperception and slowed cognitive capacity. Fatigue affects human performance adversely, resulting in predictable changes, not only on the individual level, but also on the system as a whole.

This study proposed a quasi-experimental design to examine the relationship between sleep quantity, participant's PVT scores, and actual aircrew performance as measured by RMS deviation from track on simulated mine hunting missions. The study was executed according to plan except that aircraft maintenance considerations precluded the collection of operational performance data.

Study participants were qualified helicopter aviation personnel. We examined demographic variables along with sleep quantity (measured by actigraphy), self reported sleep quality, sleep apnea risk, caffeine and alcohol consumption, and Epworth Sleepiness Scores. Because we could not collect the operational performance data, these variables could not be used as predictors of actual performance. These variables could, however, be compared to the predicted effectiveness as calculated by the Fatigue Avoidance Scheduling Tool (FAST) to determine the strength and direction of relationships between covariates. Sleep patterns of officer and enlisted participants were examined and significant differences were found between these two groups.

Despite a number of factors that altered the original study design, significant differences in amount of sleep, sleep quality and predicted effectiveness of personnel by officer-enlisted status were identified. During this study period, some members of both officer and enlisted community were sleep

deprived, receiving less than the recommended level of sleep. Enlisted personnel slept significantly less than their officer counterparts on Mondays, Wednesdays, and Fridays. This disparity in the quantity of sleep is reflected in their predicted effectiveness as calculated by FAST. Further study is needed to determine if this reduction in predicted effectiveness manifests in operational performance. If validated, this finding demonstrates an important issue to the safety and operational success of aviation mine hunting capabilities.

I. INTRODUCTION

A. BACKGROUND

Detailed research conducted over the past forty years has conclusively determined that varying degrees of sleep loss, shifts in the timing of sleep, increased stress, and even changes in time zone with respect to daylight transition result in alterations in physiological and psychological functioning (Helmreich, 2000). Military pilots and other aircrew experience these conditions regularly as they operate in challenging combat and training environments. As Helmreich and Davies (2004) demonstrated, fatigue due to disrupted sleep patterns can result in diminished mental capacity, slowed reaction time, increased spatial disorientation, propensity for miscommunication, sensory misperception and slowed cognitive capacity. These symptoms have been cited as causative factors contributing to aviation mishaps, jeopardizing personnel, aircraft and mission success (Yacavone, 1993; Erwin, 2000).

Fatigue affects human performance, resulting in predictable changes not only on the individual level but also on the system as a whole. An examination of the health hazards associated with fatigue and its detraction from aviator performance encompasses several domains within Human Systems Integration. A comprehensive understanding of the effects of fatigue on safety, survivability, training and personnel practices of the US Naval forces can be employed to minimize hazards and thus contribute to a safer and more effective system.

B. OBJECTIVE

This study used actigraphy and survey data to describe the sleep differences between enlisted and officer participants and their associated predicted performance using the Fatigue Avoidance Scheduling Tool (FAST). Until recently, much of the research incorporating the use of the FAST has focused on the corroboration of subjective assessments. Typically, researchers study the extent of sleepiness or fatigue experienced by subjects using the FAST to provide a quantifiable measurement to predict performance under varying states of fatigue. Studies of airline transport pilots have been successful in determining the effects of sleep shifts, circadian influence and the development of optimized scheduling tools.

This study builds on the understanding that individual Psychomotor Vigilance Test (PVT) scores correspond directly to performance. If substantiated in this work, the PVT score could be used as an indicator of future performance. Repeated measurements accumulated over time result in individual baselines providing data for comparison of the two subject populations. It is anticipated that over time, enough data could be collected to formulate a negative performance threshold. This threshold value could then be used to predict negative performance potential in aviators. Predicted safety of flight could then be calculated and empirically-based decisions could be made as to whether or not the pilot should fly.

C. LIMITATIONS AND ASSUMPTIONS

The participants were screened for possible sleep disorders. It was assumed that the baseline sleep level is representative of the performance during full rested conditions. Despite the limited duration of the experiment, the design allowed for the formulation of a baseline FAST performance threshold for each individual participant. Due to the number and nature of the assumptions being made, this project should be viewed as a demonstration and springboard for further research to support any possible findings that may be identified.

II. LITERATURE REVIEW

A. MISSION

The mission of the US Navy HM (Heavy-lift Airborne Mine Countermeasures) community consists of long periods of low-intensity workload accompanied by intermittent high intensity/high workload conditions requiring high levels of skill and coordination. The MH-53E helicopter is the largest and arguably the most complex helicopter in the US Navy. Crews typically fly four-hour missions towing a "sled" deployed from the rear of the aircraft. The sled is pulled along the water's surface via a several thousand foot long cable which passes dangerously close to the tail rotor. Once the sled is deployed, the aircrew must remain vigilant throughout a long and detailed search pattern. This sustained vigilance results in high levels of fatigue-related errors, particularly when coordinating launch and recovery operations. Aircrew fatigue has proven to be a critical factor in several of the most recent accidents experienced by the aviation community (Personal communication with Captain Neubauer, Naval Safety Center, 17 April 2006).

Research demonstrates that individuals are not able to accurately predict their own performance impairment during a week of alternating shift schedules (Dorrian et al., 2003). To compensate for changing schedules, military requirements mandate eight hours of uninterrupted rest prior to pilot flight operations, with a maximum twelve flight-hour duty days, as well as weekly, monthly and yearly flight hour maximums. Chronic sleep restriction over an extended period results in a condition known as sleep debt (Hardaway & Gregory, 2002). Individual performance does not return to normal levels even after three days of rest (Belenky et al, 2003; Lenne, Triggs, & Redman, 1998).

Porcu, Bellatreccia, Ferrara, and Casagrande (1998) found that shift workers, who are often involved in night-time operations and irregular work schedules, frequently complain of nocturnal sleepiness. The work schedules of military pilots mirror those of shift workers in that their schedules operate 24 hours a day and are subject to wide fluctuation due to operational requirements. The added demands placed on military pilots due to multiple time zone shifts and irregular scheduling undoubtedly result in decreased performance and increased sleep debt.

For military pilots, deployments result in an increase in preparation duties during both arrival and departure for home. Each deployment requires additional tasking which further adds to pilot stress and fatigue. Loh's (2005) doctoral thesis highlights the value of regulating not only the number of flying hours, but also the length of the flight duty period within the flying hours encompassed. The proposed constraints are particularly important with respect to multi-sector days, since flight crews are likely to spend a significant amount of time on the ground between flight sectors. When deployed, flight hour requirements typically remain the same as when stationed at home. The ability to objectively assess fatigue levels both at home and when deployed is essential to avoid catastrophic systems failure due to unrecognized fatigue (Hardaway & Gregory, 2002).

The U.S. Navy uses Operational Risk Management (ORM), a subjective survey system that assesses risk using weighted questions covering a myriad of factors that may influence the safe execution of an operation. ORM is fundamental in preparing for any dangerous operation in the Navy and within the aviation community. The ORM survey includes questions about an individual's life stressors, nutrition, and rest over the days prior to a given flight (OPNAVINST 3500.39B, 2004). The Operational Risk Management Assessment System (ORMAS) is an extension of the ORM program. The ORMAS is an attempt to provide a quantitative picture of a squadron’s safety posture, considering both the overall health of the squadron and the safety risks inherent in current operations.

B. PSYCHOMOTOR VIGILANCE TASK

The Psychomotor Vigilance Task (PVT) provides a validated and objective measurement of an individual’s fatigue state (Dinges, 1985). The hand-held PVT test developed at the Walter Reed Army Medical Center has proven to be an exceptional tool for detecting fatigue related changes in reaction times. Shorter reaction times are indicated on the Palm-based program as a decrease in the time it takes to respond to the visual stimulus. The hand-held PDA version of the PVT is suitable for use in aviation (Balkin et al. 2004). The device's portability, coupled with its practical use as a PDA, makes it a likely candidate for use in military scenarios since the PVT is objective, has proven to be effective at discriminating fatigue levels, and takes little time to administer.

Recent research completed at Walter Reed Army Institute of Research (WRAIR) (Balkin et al. 2004), determined that the Palm-based PVT was the most sensitive measuring device for monitoring sleep restriction in field studies. The PVT was second in accuracy and sensitivity only to the Sleep Latency Test (SLT) which must be completed in a laboratory setting using polysomnographic (PSG) equipment.

The WRAIR research team concluded from their study that the sensitivity of the PVT is dependent not only upon fatigue level but also upon the type of sleep deprivation and the nature of the task test in terms of length, time of day and number of times it is administered daily (Balkin et al., 2004). They suggest that there might be PVT score differences due to the physiological effects of total sleep loss versus partial sleep loss. It is therefore possible that the two different types of sleep loss will also produce different task sensitivity profiles. Researchers clearly determined that it is not feasible to conduct a study, or series of studies, which could account for circadian rhythm, the type of sleep loss, and the effect of the number of daily administrations of the PVT simultaneously (Balkin et al., 2004). Instead, they recommended further research into the development of Bayesian decision process models to identify key performance values which can be applied with improved sensitivity. Researchers concluded that the PVT should be regarded as the leading candidate among the measures tested to date.

There have been great strides forward in flight scheduling proficiency, but it is still difficult to account for the anomalies which often arise due to the changing nature of flight operations. Sleep debt, jet lag, stress-induced fatigue, short notice emergency flights for medical evacuation and search and rescue are all situations that undermine even the best scheduling algorithms. Delays due to maintenance failure or operational issues further complicate the situation by pushing individual crew-day limits. During a normal briefing time, the schedule may be optimized for an aviators' performance only to have the schedule slide into an unsafe flight window as a result of unforeseen delays.

Research has demonstrated the general inability of humans to assess their own fatigue level (Dorrian et al., 2003). Often, aviators will opt to accept missions with a higher purpose, such as medical evacuation flights or operationally significant missions. The level of motivation and arousal inherent to the mission can further cloud their judgment when making a personal fatigue assessment. Fatigue rating accuracy is improved with tasks providing performance feedback, such as the PVT. After seeing their scores, individuals have a more accurate perception of their performance due to the corroborative nature of the test.

The personal computer (PC) version of the PVT has been effectively used in two major fatigue studies. Both studies reinforce the choice of incorporating the PVT as an objective measure of fatigue. A jet lag study using the PVT was conducted on a 747-400 flight from Auckland to Los Angeles to Frankfurt to Los Angeles to Auckland (Powell, Petrie & Norrie, 1998). This study was aimed at ensuring that PVT measures were consistent at determining whether the methodology could be self-administered. The study also incorporated the measurement of salivary melatonin for corroboration of sleep deprivation. The fatigue results were consistent between the different measures, indicating that self-administered testing with the PVT was feasible (Powell, Petrie & Norrie, 1998). These findings were further supported by a study by Rhodes and Vincent (2000) in which they determined that the best predictors of a pilot’s fatigue level were cognitive and psychomotor test performance.

The 10-minute version of the PVT has been studied to determine if it differs from tests of shorter duration. Two separate studies found that performance on the 5-min PDA-PVT closely tracked that of the standard 10-min PVT during the measurement of individuals with long hours of sustained wakefulness (Lamond, Dawson & Roach, 2005; Van Dongen & Dinges, 2005). However, the shorter the task sampling time, the less sensitive the test is to sleepiness. While the 5-min PVT may provide a viable alternative to the 10-min PVT for some performance metrics, subjects need to complete the full 10-minute task in order to effectively test for performance degradation (Loh, Lamond, Dorrian, Roach & Dawson, 2005).

C. CONFOUNDING FACTORS

A number of confounding factors have been noted to mask subject performance on the PVT such as motivation, caffeine, and individual physiological response to fatigue. These factors have been investigated by a number of researchers. With respect to motivation, subjects may perform better on shorter tasks. Studies have shown that motivation frequently masks decrement in reaction times on the shorter duration PVT (Van Dongen & Dinges, 2003). The 10-minute test is more effective at mitigating the effects of motivation. In addition to motivation, caffeine intake can mask performance decrement by reducing reaction times in participants who are not habitual caffeine users. Debate exists as to whether habitual caffeine users are returned to a regular performance state after consumption of caffeine (Van Dongen et al., 2001).

Individuals differ in their reaction to fatigue not only physiologically, but also psychologically. It is becoming increasingly clear that inter-individual differences in sleep need, vulnerability to fatigue and circadian phase should be taken into account when studying the neurobehavioral consequences of sleep deprivation or circadian desynchrony (Van Dongen & Dinges, 2003). In fact, Van Dongen, Maislin, and Dinges (2004) determined that over 50 percent of the total variance in individual differences in PVT score in response to sleep loss could be accounted for by individual physiological and psychological characteristics. Additionally, though individual reaction times remain fairly consistent between the ages of sixteen and sixty, beyond this range research has shown that age and gender are affected differently by sleepiness and circadian phase shifts. Within the course of 24 hours, individual PVT scores can vary; however, daily mean PVT scores remain consistent (Van Dongen, Maislin & Dinges, 2004).

Research has shown that PVT performance is highly sensitive to changes in alertness/drowsiness associated with circadian phase (Wyatt et al., 1997), acute total sleep deprivation (Dinges et al., 1994), cumulative partial sleep (Rowland et al., 1997), sleepiness in the elderly (Samuel et al., 1996), shift work/jet lag (Rosekind et al., 1994), the demands of medical house staff (Geer et al., 1995), and with untreated obstructive sleep apnea in clinical populations (Kribbs & Dinges, 1994). The ability to discriminate differences in alertness, sleepiness and drowsiness, mediated by learning effects and aptitude, makes PVT lapses an ideal criterion for testing the validity of biobehavioral monitors intended to detect performance impairment resulting from hypovigilance, drowsiness or fatigue as it relates to drowsy flying.

III. METHOD AND DESIGN

A. PARTICIPANTS

The participants in this study were 26 naval aviators and air crewmen assigned to a Helicopter Squadron located in Norfolk, VA. Participants were Aviation Warfare qualified pilots and aircrew assigned to the squadron and fully qualified for mine hunting duties. Participant ages ranged from 22 to 41 years with an average age of 30.8 years (*s.d*. = 6.1 years) All aircrew and pilots received rigorous medical screening examination prior to and throughout their tenure on aviation duty as required by US Navy standards. Since all participants were cleared for flight duty, it was assumed that this group was healthy. Volunteers for this study were not compensated other than as part of their current military duties conducted over the same period. All volunteers were treated in accordance with the "Ethical Principles of Psychologists and Code of Conduct" (American Psychological Association, 1992a).

The demographic profile of the study participants, collected by self report, is presented in Chapter IV. Squadron operations were conducted during a five-day work week, with weekend flights supported by essential personnel only. The schedule for flights and squadron operations was rigid, predictable, and communicated to all personnel via a published plan of the day. Pilots and aircrew have training and collateral projects throughout the entire week, as well as fulfilling their primary duties within the squadron.

The participants in the study received a battery of tests including a demographic survey, the Epworth Sleepiness Scale, and a screening test for sleep apnea. They also received wrist activity monitors (WAMs)—along with instructions for their use and care—on 7 July 2006, and data collection began on that date. One WAM malfunctioned early in the study, reducing the sample from 26 to 25. The original intent was for the participants to wear the WAMs over a 14 day data collection period; actual data collection time ranged from 10 to 21 days. The data collection period for enlisted participants ended on 20 July 2006 while data collection for officers ended 10 August 2006. The dates of data collection for the aircrew were extended in an effort to collect operational performance on flight performance. Unfortunately, mechanical difficulties on the helicopters precluded the operational performance data (mine hunting) but the method for accomplishing this in future studies is now available.

Activity and sleep logs were used during the data collection period to capture data regarding naps, sleep/wake times, participant affective mood, and exercise periods. At the end of the data collection period, the data were downloaded from each actigraph. Following data cleaning and consolidation, the data were analyzed using commercial sleep and statistical analysis software.

B. MATERIALS / APPARATUS

Each participant was issued a data collection package consisting of a set of instructions with data sheets, one PDA, and one wrist activity monitor. The PDAs issued were either Handspring Treos or Handspring Visors loaded with Palm OS 3.0 software or above. The PDAs were preloaded with software to run the Walter Reed Palm-held Psychomotor Vigilance Task which timestamps and records all scoring attempts.

1. Actigraphy

Actigraphy has been shown to adequately discriminate between states of wakefulness and sleep (Jean-Louis, Kripke, Mason, Elliott, & Youngstedt, 2001). It is also a valid and reliable estimate of sleep when compared to polysomnographic measures of sleep in various groups of research participants (r=.93 to .99) (Ancoli-Israel, Clopton, Klauber, Fell & Mason, 1997; Brown, Smolensky, D'Alonzo, & Redman, 1990).

The study used MotionLogger Actigraphs, manufactured by Ambulatory Monitoring Inc., Ardsley, NY. The MotionLogger contains an accelerometer that detects motion. These motion detections are then stored in the device for later download. A more detailed description of the MotionLogger functional capability is provided in Section D.2. Prior to beginning data collection, each WAM was calibrated and initialized to begin data collection. Initialization consisted of programming the WAMs for current date and to begin collecting data at 1-minute time intervals, known as the epoch length.

The data from each MotionLogger were downloaded throughout the data collection period to ensure data recovery in the event of a catastrophic failure and again upon completion of the study period for initial analysis using the ActME program. This program calculates such items as sleep duration, sleep efficiency, and sleep latency. The ACTMe data were then exported for further analysis using the FAST software program.

The ActME software uses raw MotionLogger data to generate quantitative and visual representations of a subject's activity, and this output is known as an Actigram. Activity is represented in the Actigram window by vertical bars. Generally speaking, the height of the vertical bar indicates the amount of movement that was sensed by the MotionLogger and provides a graphic display of both frequency and intensity of movement. Information is generated for each day on sleep start and end times, total time in bed, assumed sleep time, and sleep efficiency. See Figure 1 for an example of a single day's output from a wrist activity monitor.

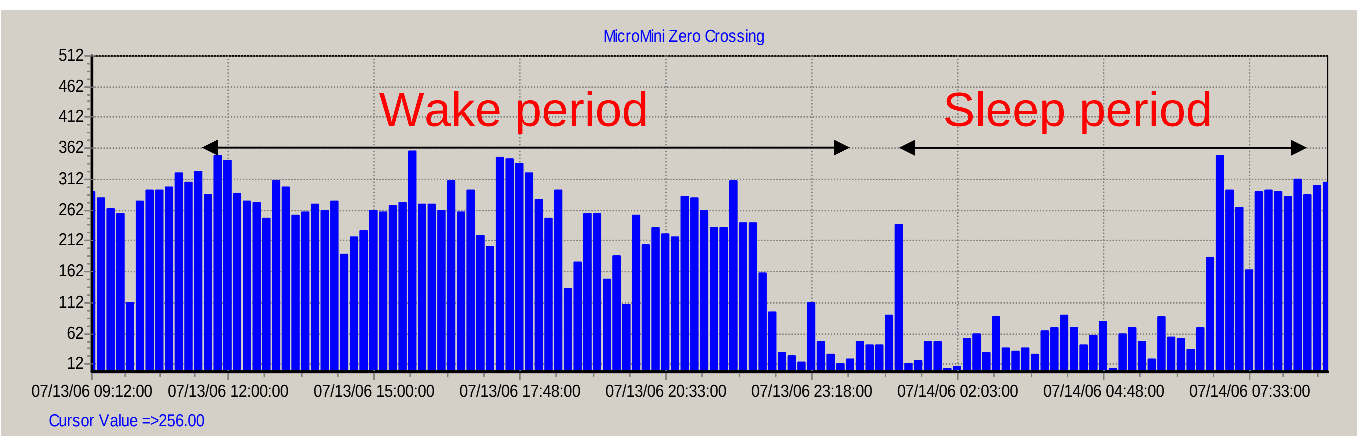

Figure 1. Sample Actigram for a Single Day

C. DESIGN OF THE STUDY

As originally designed, the study is quasi-experimental, consisting of two data collection periods of 7 days each. Detailed discussion of the independent and dependent variables are provided below as sections D and E.

D. INDEPENDENT VARIABLES

1. Quality of Sleep

Participants were asked to record their activity during the duration of the study using a paper and pencil activity log. The activity log consists of a chart broken down into quarter hour intervals with space for participants to record the type of activity performed during each period. Participants were instructed to record all activities performed throughout the day in 30-minute increments. They were also asked to note in the log the times at which they went to sleep, woke up, or removed the actigraph.

2. Activity Measurement

Rest and activity levels were measured using a small wrist worn ambulatory activity monitor (MotionLogger Actigraph, Ambulatory Monitoring Inc, Ardsley, NY). Activity level was measured in 1 minute intervals over the period of the study and stored in memory for subsequent computer retrieval and analysis. The activity device detects movements through a piezoelectric accelerometer and is capable of detecting accelerations greater than 0.01g (up to 10 counts per second). The accelerometer generates a voltage during each movement, which is amplified and band pass filtered. The resulting signal is compared to a reference signal to determine if it exceeds a threshold for quantification and storage.

The MotionLogger is capable of recording and storing information in three different settings. In the Zero Crossing Mode (ZCM), the signal voltage from the accelerometer is compared with the reference voltage, and each zero crossing generates an activity count (range: 0-255). In the Time above Threshold Mode (TAT), the signal voltage is compared with the reference voltage and a count is generated and stored in memory every 0.1 seconds while the signal remains above threshold (range: 0-255). In the proportional integrating mode (PIM), the area under the rectified analog signal is measured for each epoch, and the accumulated count (range:0-60000) is stored in memory. The PIM measures movement intensity by summing the deviations from 0 V (i.e., the absolute value of the voltage) every 0.1 seconds. Actigraphs in the current study are set to record in PIM as this setting has been shown to be the most sensitive in previous research (Jean-Louis, Kripke, Mason, Elliott, & Youngstedt, 2001).

3. Description of PVT

The PVT task is a ‘simple’ reaction time test designed to evaluate the ability to sustain attention and respond in a timely manner to salient signals (Dinges & Powell, 1985). The task is designed to be simple to perform, free of a learning curve or influence from acquired skills (aptitude, education), and highly sensitive to an attention process that is fundamental to normal alert functioning.

PVT users are required to press a button as soon as digits appear on a millisecond counter. The digits are presented in random intervals varying from 2 to 10 seconds. During both protocols, three test sessions of 10 minutes each were performed throughout the day, starting with reporting to duty every morning, noon, and end of work day. Additionally, the PVT was scheduled to be taken 30 minutes before and after each flight/simulation. During the orientation phase, two PVT sessions were administered to familiarize the participants with the task. All participants were instructed to press the response button as fast as possible after the digits appear.

4. PVT Lapses

When scoring the PVT, a lapse is defined as any reaction time greater to or equal to 500 ms. Lapses represent a failure to respond (or failure to respond in a timely manner) to a signal monitored by the observer and indicate a loss of attention capacity. Number of lapses for each 10 minute PVT (i.e., global index of vigilance performance impairment for each bout), and the number of lapses in each minute of PVT performance throughout each 10 minute PVT (i.e., minute to minute fluctuations in vigilance performance), were recorded. Total lapse time for each 10 minute PVT and the total lapse time per each minute of PVT performance throughout each 10 minute PVT were also recorded.

To account for individual differences, separate PVT banks were created for each individual. Effective utilization of PVT scores as an objective measurement tool requires a baseline average to be calculated for each individual. Performance on the PVT reflects a circadian modulation of neurobehavioral functions, as well as the effect of sleep pressure developing with duration of time awake (Graw, Krauchi, Knoblauch, Wirz-Justice & Cajochen, 2004). When determining an individual's baseline on PVT, scores must be segregated throughout the day to take into account individual differences (Van Dongen, Maislin & Dinges, 2004).

5. Measures of Sleepiness

The demographic survey included the Epworth Sleepiness Scale, which determined the participant's usual level of daytime alertness or chronic sleepiness. Information was gathered on hours of sleep and sleep patterns immediately before flying. Usual patterns of sleep and work were also reported.

6. Demographic and Other Variables

Gender, race, rank, age, operational experience, general health status including caffeine intake, number and age of family members residing with participant, and physical fitness scores were used as covariates. Affective measures such as feelings of stress, alertness, irritability, and mood state were also collected through self-report responses on a Likert-type scale. Sea state, wind and other pertinent meteorological data were collected and included in the analysis to rule out possible confounding due to differences in weather during testing.

7. Data Availability

One concern with the data collection was a systematic approach for tracking an individual's sleep and demographic data while ensuring participant anonymity. Matching demographic data with sleep data was crucial to the study. Last names and numeric participant identifiers assigned to each MotionLogger were used to build a spreadsheet with all the demographic and actigraphic data matched to the participant. At one point, this involved cross-checking four spreadsheets simultaneously. Once that was accomplished, a spreadsheet without identifying data was generated to use in analysis.

E. DEPENDENT VARIABLE

The mine sweeping equipment used by the squadron can be classified into two categories by design purpose: counter contact and influence mines. For “contact-detonated” mines, the current version of the countermeasure equipment consists of towing a pair of long float-supported wires that flare out into a giant "V" underwater. The wires guide a mine's mooring cable into the jaws of explosive cutters spaced along the wire's length. The other class of minesweeping gear is designed to work against mines that are set off by the sound or magnetic signature of a passing ship. These "influence" mines can be either scattered along the ocean floor or tethered. Tethered influence mines are much deeper in the ocean than contact mines, so they are harder to unmoor. To sweep for influence mines, the Navy uses another kind of gear. The countermeasure device or “the sled” consists of a platform trailing two long, electrically charged tails. The charge creates a magnetic field, and any mines present will interpret the field as the magnetic signature of a ship's hull. For a more complete sweep, another device can be attached to one of the tails. This "noisemaker" is essentially a float with a small funnel that sucks in water; inside, a disk churns the water to simulate the sound of a ship's cavitating propellers.

The pilots on minesweeping missions must fly straight tracks back and forth, often for miles at a time, so that every inch of a suspected mine field can be covered. The helicopter, however, is often buffeted by wind and the motions of the sled in the waves below. Towing a sled on a straight path in these conditions requires constant vigilance and attention. Contrary to standard training protocols, which require pilots to execute coordinated turns in which the aircraft is neither slipping in toward the turn nor skidding out away from it, mine sweeping with tow equipment requires the pilot to make these kinds of slips and skids regularly. When one track is completed, the helicopter executes a turn to proceed down the next. Nearly 1,000 feet of flying and floating machinery has to be kept as straight as possible. A properly executed turn is like a pivot on a point, with the helicopter slowly slewing around like the hand on a clock. Deviations from the ideal track are measured by global positioning system navigation equipment onboard the helicopter.

Inability to execute track navigation with precision results not only in errors of mine detection and blank areas in the search grid known as “holidays,” but also endangers the aircraft and crew. Since the tow bar swings freely inside the helicopter, the pilot has to keep it aligned with the center of the helicopter or a collision of boom, wall, and crewman will result, leading to the crewman and a section of the boom ending up outside the aircraft.

The dependent performance measure proposed in the study was deviation from the two dimensional search track during simulated mine sweeping operations, calculated as the root mean squared (RMS) distance from the planned flight path. This dataset is in the form of GPS data captured as a standard performance metric by the squadron’s tactical analysis branch. Unfortunately, due to mechanical issues in the squadron aircraft at the time of data collection, these data were not available to be included in the study. The method for their inclusion is listed here so that it will be available for future researchers.

F. PROCEDURES

1. Participant Selection

A pool of potential participants was provided by command staff of an operational helicopter squadron. A screening survey was administered to collect the age, gender, sleep history, caffeine intake, and the ability to complete the two week study without substantial interruption of each potential participant. Those individuals who did not meet the inclusion criteria were provided with a brief explanation of why they were not able to take part in the study.

The study collected information on daily caffeine use. Habitual caffeine use (less 250mg) per day was permissible. If participants were normal coffee drinkers or soda drinkers, they were asked to maintain the same regimen throughout the study in order to keep PVT data consistent (Van Dongen et al., 2001). Although age is a consideration with the PVT, all participants were within the 16-60 year PVT accuracy envelope. Those volunteers who met the inclusion criteria were scheduled for orientation to the study, which included completion of demographic survey, Epworth Sleepiness Scale, sleep apnea screening, statement of consent and privacy act, and training on the PVT and MotionLogger.

2. Actigraph Measurement and Self Monitoring Procedure

Following the questionnaire administration, participants were provided a MotionLogger actigraph to wear for the duration of the study and were monitored daily. The participants were instructed to wear the actigraph for the duration of the study and not remove it during the study period except when showering or swimming. During the study activity monitoring period, participants were asked to keep a written log of their level of activity throughout the day. Participants returned to the investigator for periodic download of actigraphs, PVT data, and activity logs.

Participants were instructed to maintain a regular sleep–wake-cycle (bed- and wake-times within ± 30 min of self-selected target time), which was verified by wrist activity monitors and sleep logs. The sleep–wake schedules were calculated by centering the 8-hour sleep episodes at the midpoint of each individual's habitual sleep episode as assessed by actigraphy and sleep logs.

When participants returned the actigraph, the data were downloaded into a computer for analysis with ActME, and FAST software. The software allows for sleep-wake scoring and creates and analysis file for each import. These files include information for four different intervals: 'up', 'down', '0-0', and '24 hour'. 'UP' consists of all time spent in the waking state. 'Down' consists of all time spent in sleep or attempting to sleep, including sleep latency (i.e., the amount of time it takes the person to fall asleep). '0-0' consists of time spent sleeping with sleep latency removed (i.e., the best estimate of actual sleep time). '24 hour' consists of the entire measurement interval. In the current study, '0-0' was used as the estimate for sleep as it eliminates sleep latency.

3. Performing the PVT

The PVT task was loaded into every PDA provided to the participants. The task consisted of participants responding to a small light stimulus on the PDA screen by pressing a response button on the hand-held device as soon as the stimulus appeared. Pressing the button stopped the stimulus counter and displayed the reaction time in milliseconds for a period of 1 second. The inter-stimulus interval was preset to vary randomly from 2 seconds to 10 seconds with total test duration of 10 minutes. Participants were read the following instructions during training sessions for the experimental protocol:

> During the test, as soon as you see the stimulus on the PDA, press and release the button using your preferred hand, that is, the hand you typically write with, on the hand-held response box. You may use your thumb or finger, but once you have decided, always use the same finger for all subsequent tests. The numbers in the display show how fast you responded each time – the smaller the number, the better you did. This is your reaction time in thousandths of a second (or milliseconds). Your task is to pay close attention to the stimulus window for the full 10 minutes of the task and respond by pushing the button as quickly as possible when you see the stimulus. The lower the number, the faster your reaction time. However, don't try to guess or anticipate the stimulus by hitting the button too soon – in which case you will see an error message indicating a false start. If you press the other button on the PVT you will see a message indicating an error. Try to do your best and get the lowest number you possibly can, avoiding false starts and errors.

Prior to each testing throughout the period of study, subjects were reminded to push the button as soon as each stimulus appears during the PVT in order to keep their reaction times as low as possible but not to press the button too soon.

4. Debriefing

Participants were thanked for their participation and all participants received a debriefing information sheet, information on sleep and performance, and a list of instructions to improve sleep hygiene factors.

G. ANALYSIS PLAN

For the first step of the analysis, MotionLogger data were imported into Microsoft Excel® and SPSS. Frequencies and graphs of the dependent measures were examined to ensure data quality. Box plots were generated to visually assess possible differences.

Upon completion of the initial analysis using the ActME program, the daily sleep duration for each subject was analyzed using Microsoft Excel®. Average and median sleep duration for each subject was calculated based on the total number of days of participation by each subject. The mean nightly sleep for each subject was then recorded for population analysis. In addition, the crew members with the most, median, and least amount of mean nightly sleep were identified. Data were then input into another software program, called the Fatigue Avoidance Scheduling Tool (FAST). The FAST output is a graph of predicted task performance, based on sleep and naps obtained by the participant. The FAST output also may include a blood alcohol content equivalence on the right side of the output. A five day example of FAST output is provided as Figure 2 from Miller, 2004. This scale is designed to equate the level of individual sleep deprivation with the equivalent performance typically experienced by a person following alcohol ingestion.

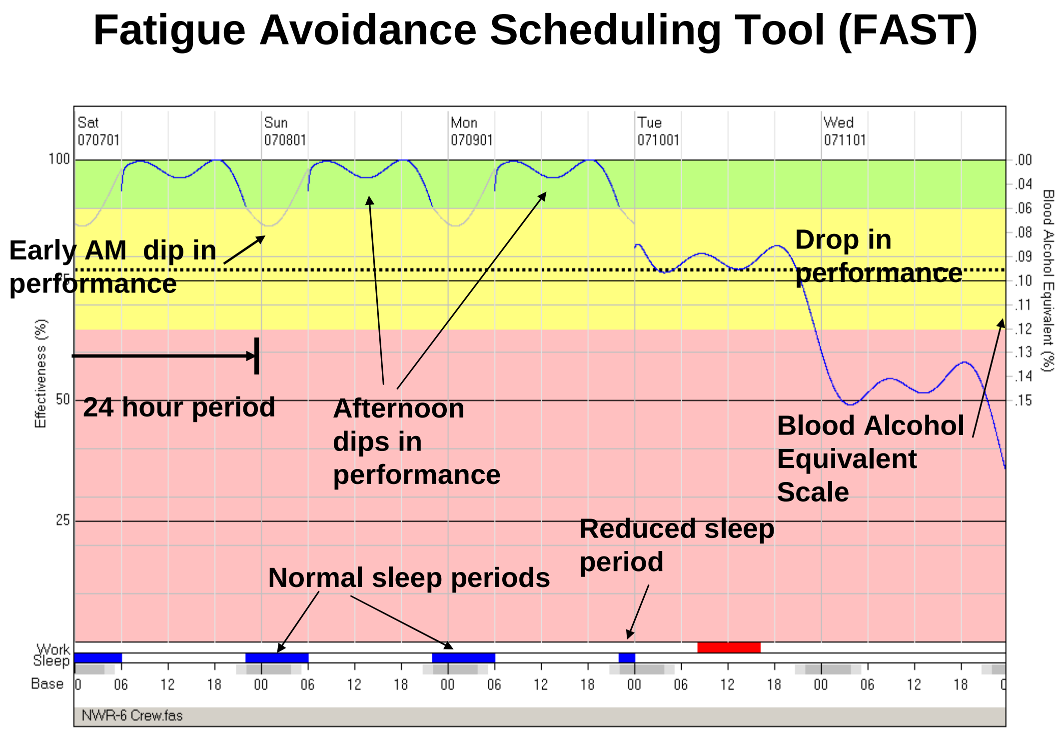

Figure 2. Sample FAST Output for Five Day Period from Miller, 2004

As seen in Figure 2, FAST displays individual predicted effectiveness in terms of green, yellow and red bands. The green band represents acceptable predicted effectiveness associated with a blood alcohol equivalency range from 0.00 to 0.06 and indicates little or no decrement in predicted effectiveness. When individuals receive eight hours of sleep per night, their waking predicted effectiveness stays in this zone. The yellow or cautionary band indicates some decrement in predicted effectiveness and is associated with a blood alcohol equivalency range between 0.06 and 0.12. The red or danger band indicates substantial loss of predicted effectiveness due to fatigue and is associated with impairment equivalency of blood alcohol greater than 0.12. The dotted line seen at 78% effectiveness is the cut-off level used by the USAF when calculating work/rest regimens on their long-duration missions, e.g., B-2 missions of 40 hours in length. During these flights, the pilot in command must have a predicted effectiveness greater than 78%. During all mission critical phases of the flight (e.g., take-off, air-refueling, ordnance delivery, and landing), the predicted effectiveness level must be in the green band.

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IV. RESULTS

This study was conducted on personnel in an operational MH-53 helicopter squadron. This aircraft requires a relatively high amount of maintenance. Unfortunately, maintenance requirements during the two week study precluded the collection of operational performance data. Despite the inability to measure operational performance, we were able to collect data on the sleep patterns and the predicted performance of enlisted and officer personnel in the squadron and the results of this work are presented here. PVT Data was also collected for comparison to the operational performance measures. However, in the absence of operational performance data, PVT data was excluded from the analysis in this thesis. The FAST program used PVT data as the foundation for development of the predicted effectiveness algorithm. Therefore further correlation of squadron PVT and predicted performance data was unnecessary.

A. STATISTICAL ANALYSIS

Twenty-five pilots and aircrew personnel participated in the study. Demographic data are provided in Appendix A. Measures of central tendency for appropriate scalar variables are provided in Appendix B. In order to determine statistical significance when comparing categorical groups, the Tukey-Kramer “Honestly Significant Difference” (HSD) Test with a=0.05 was utilized.

1. Sleep Minutes by Officer-Enlisted Status

The average amount of nightly sleep in minutes for each participant was used for the statistical analysis. On average, participants in the study received approximately 7hrs, 28min (*s.d.* = 1hr, 39min) of sleep per night. Average sleep in minutes by officer-enlisted status is provided in Table 1.

Table 1. Average Nightly Sleep Minutes by Officer-Enlisted Status

Descriptive Statistics

Grade		N	Range	Minimum	Maximum	Mean	Std.	Variance	Skewness		Kurtosis	
		Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
off	Sleep Minutes	146	618	258	876	468.48	100.487	10097.548	.727	.201	2.379	.399
	Valid N (listwise)	146										
enlist	Sleep Minutes	87	509	175	684	422.08	94.541	8937.959	.444	.258	.679	.511
	Valid N (listwise)	87										

A histogram of the study sample, using 20-minute bins from four hours to seven hours of sleep per night is presented in Figure 3 and shows a relatively normal distribution of minutes slept among total study population.

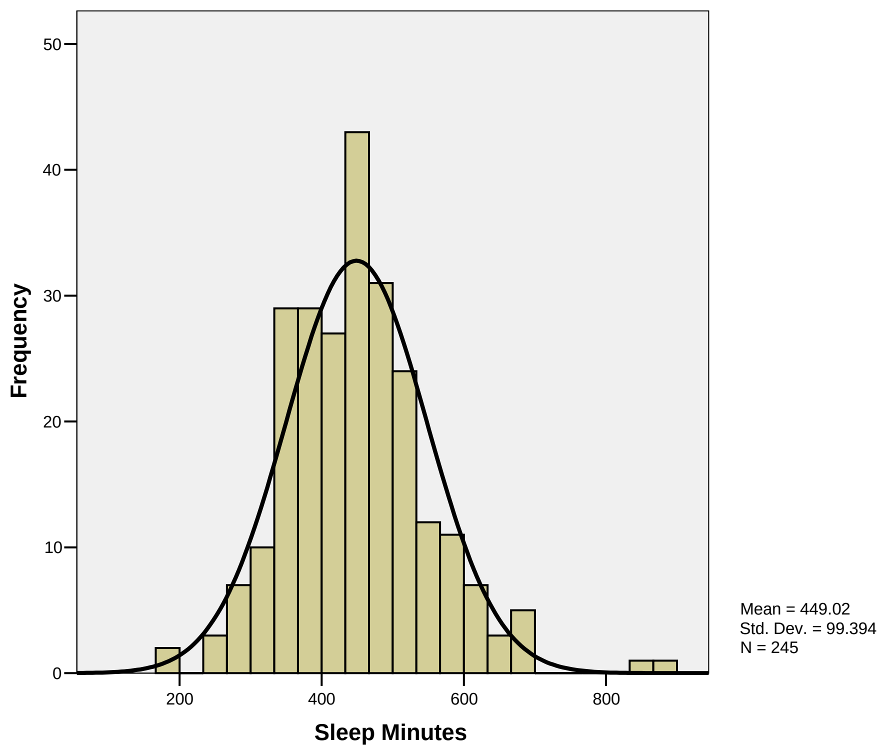

Figure 3. Distribution of Average Sleep Quantity

Sleep quantity was assessed between enlisted and officers in the study. The independent t-test results are included as Table 2.

Table 2. T-Test for Equality of Mean Sleep Minutes by Officer-Enlisted Status

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Sleep Minutes	Equal variances assumed	.001	.976	-3.208	243	.002	-41.780	13.024	-67.434	-16.126
	Equal variances not assumed			-3.253	184.645	.001	-41.780	12.844	-67.121	-16.440

Based on Student's t-test, $t(243) = -3.208$, $p = 0.002$, the officers in the study got significantly more sleep (on average, approximately 42 minutes per night) than did the enlisted personnel in the study. Daily average sleep in minutes by officer-enlisted status and day are presented in Table 3.

Table 3. Average Sleep by Officer-Enlisted Status and Day of the Week

Descriptive Statistics[a]

Grade	Starting Day		N	Minimum	Maximum	Mean	Std. Deviation
enlist	SUN	Sleep Minutes	12	351	533	410.83	52.997
		Valid N (listwise)	12				
	MON	Sleep Minutes	11	313	455	406.45	49.629
		Valid N (listwise)	11				
	TUE	Sleep Minutes	18	193	580	407.78	106.071
		Valid N (listwise)	18				
	WED	Sleep Minutes	12	319	572	402.00	68.456
		Valid N (listwise)	12				
	THU	Sleep Minutes	10	296	553	416.50	93.592
		Valid N (listwise)	10				
	FRI	Sleep Minutes	12	175	684	421.33	144.421
		Valid N (listwise)	12				
	SAT	Sleep Minutes	12	360	676	494.58	88.386
		Valid N (listwise)	12				
off	SUN	Sleep Minutes	24	295	554	412.38	61.244
		Valid N (listwise)	24				
	MON	Sleep Minutes	25	260	639	451.92	111.697
		Valid N (listwise)	25				
	TUE	Sleep Minutes	24	258	695	451.38	97.446
		Valid N (listwise)	24				
	WED	Sleep Minutes	25	296	876	504.00	133.010
		Valid N (listwise)	25				
	THU	Sleep Minutes	13	321	639	469.77	73.304
		Valid N (listwise)	13				
	FRI	Sleep Minutes	24	313	612	481.08	62.017
		Valid N (listwise)	24				
	SAT	Sleep Minutes	23	268	673	478.65	104.114
		Valid N (listwise)	23				

a. No statistics are computed for one or more split files because there are no valid cases.

Box-plots further illustrate the number of sleep minutes by day of the week and officer-enlisted status (Figure 4).

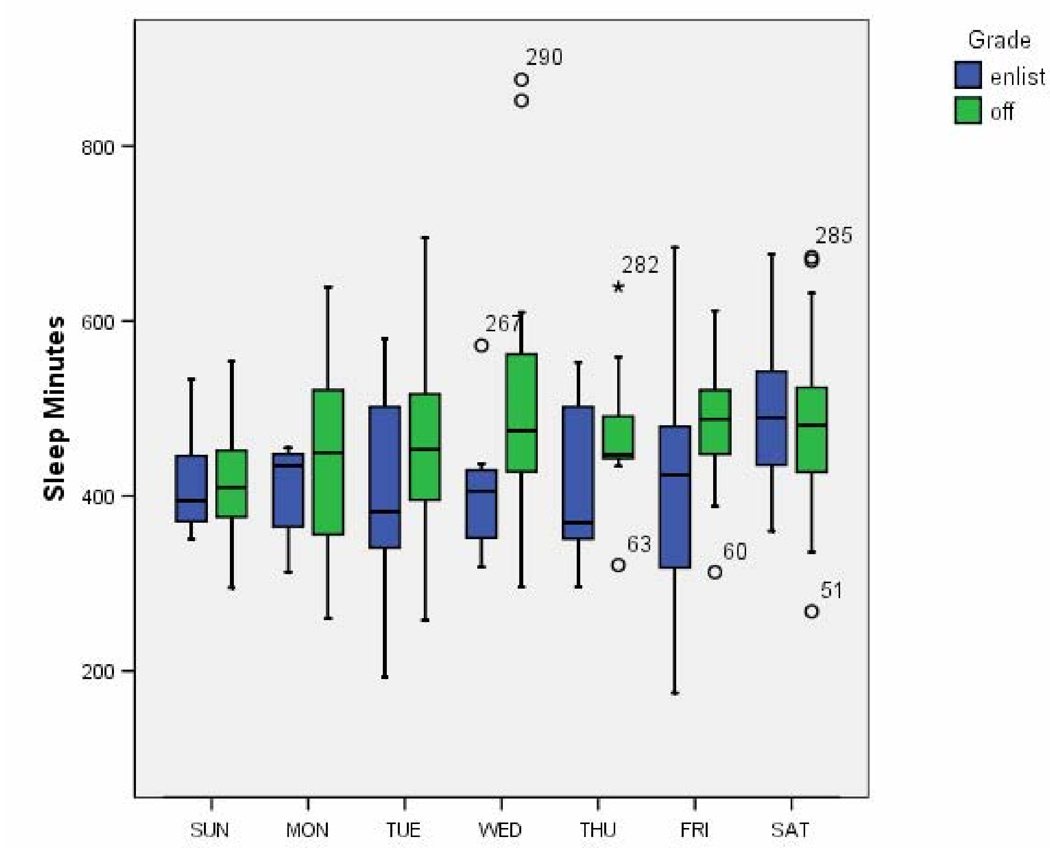

Figure 4. Sleep Minutes by Day and Officer-Enlisted Status

Daily sleep averages were calculated for each study participant. Since there were unexpected differences in the sleep received by officers and enlisted study participants, data were stratified by day of the week. Mann-Whitney U statistic was used to determine differences in daily average sleep by day of the week and by officer-enlisted status. The results of Mann-Whitney U are presented in Table 4.

On Monday and Wednesday, there were significant differences in the amount of sleep between officers and enlisted personnel with enlisted personnel getting significantly less sleep than their officer counterparts.

Table 4. Days with Observed Sleep Differentials

Day of the Week	Mann-Whitney U	Z	Sig (2-tailed)
Sun	54.50	-0.65	0.515
Mon	32.00	-2.05	0.041
Tue	40.00	-1.76	0.079
Wed	17.00	-2.98	0.003
Thu	47.00	-1.12	0.264
Fri	34.50	-1.89	0.058
Sat	52.00	-0.81	0.420

For the study period, officers received an average of 45 minutes more sleep than enlisted members on Mondays; on Wednesday, officers received an average of 1 hr., 42 min. more sleep than the enlisted study participants. On Fridays, officers received an average of 59 minutes more sleep than enlisted members

2. Correlations

Study participants were sorted by officer-enlisted status. Spearman correlations were computed to determine if relationships existed among demographic and sleep outcome measures. It should be noted that correlation does not imply causation. Statistically significant relationships are presented in Table 5.

Table 5. Significant Spearman Correlations Between Variables

Grade	Pair-wise relation			Rho	Sig
Officer	Activity mean	vs	Sleep minutes	-0.51	0.00
	Sleep minutes	vs	Alcohol	0.71	0.01
	Designator	vs	Smoking	-0.58	0.06
	Epworth	vs	Apnea	0.55	0.05
Enlisted	Activity mean	vs	Sleep minutes	-0.60	0.00
	Activity mean	vs	Education	-0.85	0.01
	Activity mean	vs	Smoking	-0.76	0.03
	Sleep minutes	vs	Number of children	-0.79	0.02
	Experience	vs	Caffine	0.73	0.04
	Experience	vs	Alcohol	0.75	0.03
	Caffine	vs	Alcohol	0.80	0.02

Examination of the results reveals a number of expected as well as unexpected and surprising relationships. Mean activity, or the average number of movements exceeding threshold per 60 second epoch during the data collection period, is negatively correlated with sleep minutes for both the Officer *P*(.00) *Rho*(-0.51) and Enlisted *P*(.00) *Rho*(-0.60) sample. Within the enlisted sample, mean activity was found to be significantly and negatively correlated to smoking *P*(.03) *Rho*(-0.76) indicating that those who smoke are less active. More surprising, however, is the significant correlation within the enlisted sample between mean activity and education *P*(.01) *Rho*(-0.85) suggesting that the more educated the enlisted person is, the less activity they engage in during waking hours.

Further, a significant negative relationship was observed between the number of sleep minutes and the number of children at home *P*(.02) *Rho*(-.76) indicating that the amount of sleep decreases as the number of children increases. Although not surprising to anyone who comes from a large family, the implications for aviation safety may be important.

Important significant and positively correlations were observed among the enlisted participants. There was a significant relationship between participant experience – in terms of years within job classification - and use of caffeinated products (including soft drinks, coffee, chocolate and dietary supplements) *P*(0.04) *Rho* (0.73). Similarly, experience was also significantly and positively correlated with alcohol use *P*(0.02) *Rho* (0.75). Lastly, the use of caffeine was positively and significantly correlated to alcohol use *P*(0.02) *Rho*(0.80). All these results confirm that as the enlisted participants' experience on the job increases, so does also their use of caffeine and alcohol.

Although fewer in number, significant findings among the officer participants include positive and significant correlation between the number of minutes slept and alcohol use *P*(0.01) *Rho* (0.71) as well as an expected but significant correlation between sleep apnea score and score of the Epworth Sleepiness Scale *P*(0.05) *Rho*(0.55). This finding suggests that participants using alcohol among the officer study population received more sleep. The moderate positive correlation between the officer's score on the sleep apnea screening score and the Epworth Sleepiness Scale indicates that those participants scoring higher for sleep apnea risk indicate being more sleepy during the course of the day.

3. Sleep vs. Sleep Quality

The quality of sleep is related to number of minutes slept but mediated by a number of factors. Although no significant difference was discovered in sleep efficiency by officer-enlisted status, there was significant difference in self-reported sleep quality between enlisted and officer respondents $F(1, 155)=10.896$, $P=.001$. The one-way ANOVA is presented in Table 6.

Table 6. Sleep Quality and Sleep Efficiency Analysis of Variance

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
SLEEPQUA	Between Groups	10.730	1	10.730	10.896	.001
	Within Groups	152.633	155	.985		
	Total	163.363	156			
seff	Between Groups	.013	1	.013	.000	.993
	Within Groups	39398.242	244	161.468		
	Total	39398.255	245			

To investigate the possible relationships between self-reported sleep quality and officer-enlisted status, we used a Spearman's correlation which indicated a negative significant relationship between sleep quality and sleep efficiency among the officer sample *P*(.000) *Rho*(-.336). This relationship between sleep quality and sleep efficiency was not seen in the enlisted study population.

Further analysis was conducted to determine factors contributing to the disparity in sleep quality between the officers and enlisted participants. The affective components of the sleep diary included self-reported levels of feeling happy, relaxed, alert, even tempered, easy going, energetic, care free, calm, and concentration. The relative differences are shown in Figure 5 which illustrates the average response to each of the mood or affective variables.

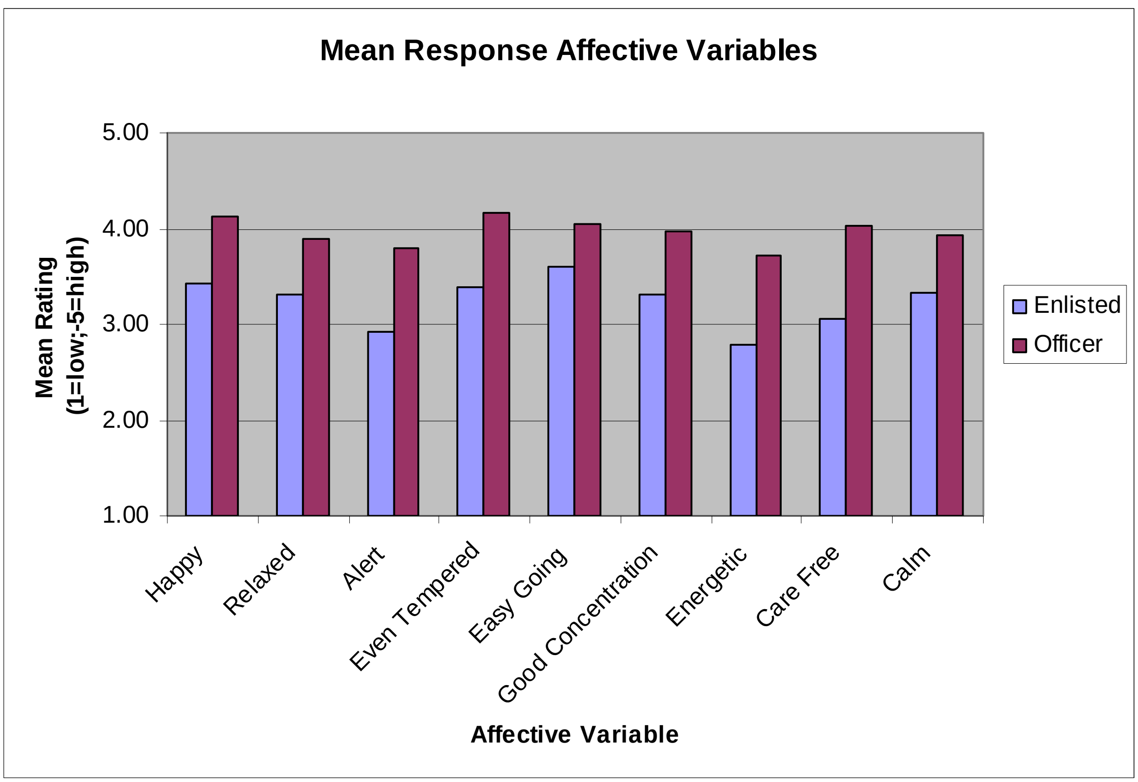

Figure 5. Mean Response of Affective Variables

The Mann-Whitney U test for differences between officers and enlisted was significant for all nine affective variables. Interestingly, the differences were in the same direction for all categories (see Table 7) with improved mood for officers as compared to enlisted participants.

Table 7. Comparison Officer-Enlisted Affective Components

Test Statistics[a]

	happy	tense	sleepy	even tempered	irritable	poor concentration	tired	worried	calm
Mann-Whitney U	1536.000	1514.000	1177.500	1212.500	1744.000	1290.000	1255.500	1150.000	1455.000
Wilcoxon W	10852.000	2180.000	1843.500	10528.500	2410.000	1956.000	1921.500	1816.000	10635.000
Z	-3.886	-3.681	-4.993	-4.908	-2.783	-4.681	-4.632	-5.104	-3.919
Asymp. Sig. (2-tailed)	.000	.000	.000	.000	.005	.000	.000	.000	.000

a. Grouping Variable: numericgrade

Aggregated correlations were put into a matrix showing all affective variables and showed that all affective variables were correlated with each of the other affective variables. This may be an indication that the measured variables are related and are reflective of a single root variable unmeasured by this study. However, sleep quantity in minutes was correlated with the level of calmness as reported by the participants - albeit the relationship was positive and weak *P*(0.047)*Rho*(.165). A correlation matrix across all the above variables, categorized by officer-enlisted status is presented in Appendix C.

B. FAST ANALYSIS

We looked at nightly sleep averages to identify squadron personnel who received the most, the least, and the closest to average nightly sleep amounts. We used the FAST software program to calculate predicted effectiveness for these participants. For the options in the FAST program, sleep was rated as “excellent” for all squadron personnel for all nights in order to maintain consistency across the results of the FAST output. This differed from the participant self-reported sleep logs in which the subjective assessment of the quality of sleep received by squadron personnel was somewhat less than optimal. This decision was made to err in the direction of being conservative in our estimates of sleep quality, that is, we gave participants credit for getting better sleep quality than they may have actually received.

Tables of predicted effectiveness were generated by day, officer-enlisted status and grand mean effectiveness and are presented in Table 8. Over all participants, the average predicted effectiveness during working hours was 87.9%. The difference between groups was surprisingly large with the mean of 80.34% for the enlisted participants while officers had an average of 91% predicted effectiveness. For the enlisted participants, their average daily mean decreases significantly over the course of the week. Their average predicted effectiveness on Thursday was 70.04% and Friday was 73.79%. The lowest daily average predicted effectiveness for officers occurred on Friday with 85.93% level.

Table 8. Mean Predicted Effectiveness from FAST

		Predicted Effectiveness					
Grade	**Day**	**Min**	**Max**	**Daily Mean**	**Std. Dev**	**Grade Mean**	**Grand Mean**
Enlisted	Mon	73.01	93.14	87.48	6.23	80.34	87.90
	Tue	56.20	95.58	85.03	11.01		
	Wed	53.56	95.73	83.49	12.76		
	Thu	56.22	88.96	70.04	11.42		
	Fri	57.36	88.10	73.79	8.69		
Officer	Mon	83.51	96.81	91.74	3.57	91.00	
	Tue	78.50	97.93	90.57	5.60		
	Wed	77.10	98.16	92.11	4.92		
	Thu	84.95	98.82	93.78	3.86		
	Fri	72.12	100.65	85.83	11.35		

These findings support the previous observations regarding the difference in average sleep between officers and enlisted on Wednesdays, as there is a marked decrement in enlisted predicted efficiency observed on the following Thursday (x=70.04, s.d.=11.0).

1. FAST Analysis for Maximum Mean Nightly Sleep

The squadron enlisted person with the highest amount of average nightly sleep received an average of approximately 8 hours 5 minutes per night throughout the course of the data collection period (see FAST output, Figure 6).

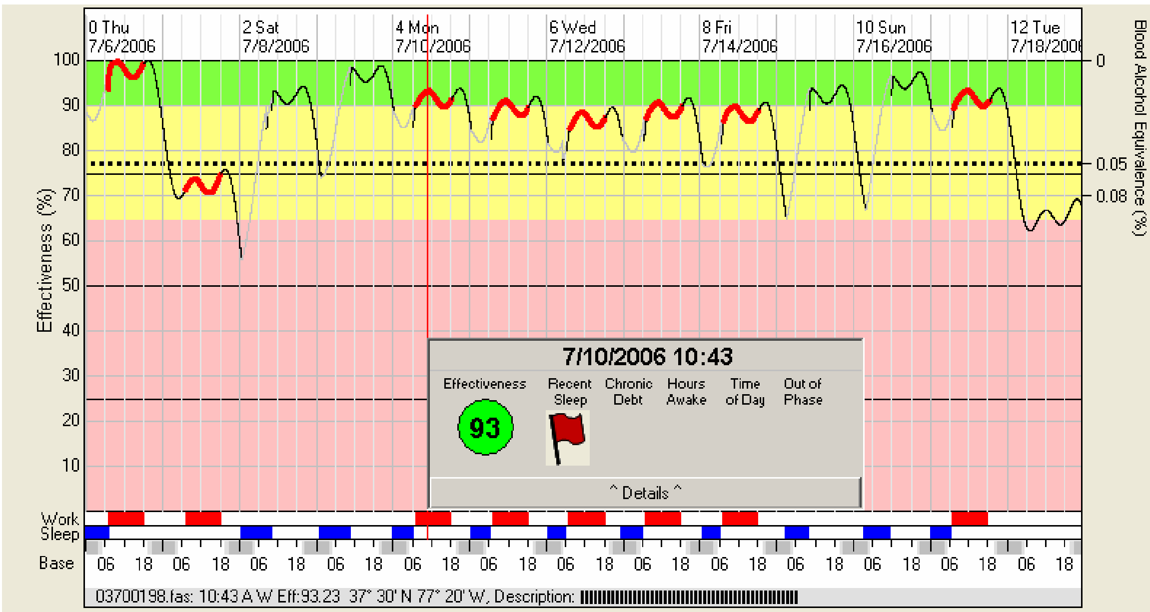

Figure 6. FAST Graphic Output for Enlisted Member with Maximum Mean Sleep

This participant's mean waking effectiveness (as calculated by the FAST software) is 88.19%. In general, this individual is operating along the border of "yellow and green" for most of the study period.

The squadron officer with the highest average nightly sleep received an average of approximately 9 hours, 42 minutes per night throughout the course of the data collection period (see FAST output, Figure 7).

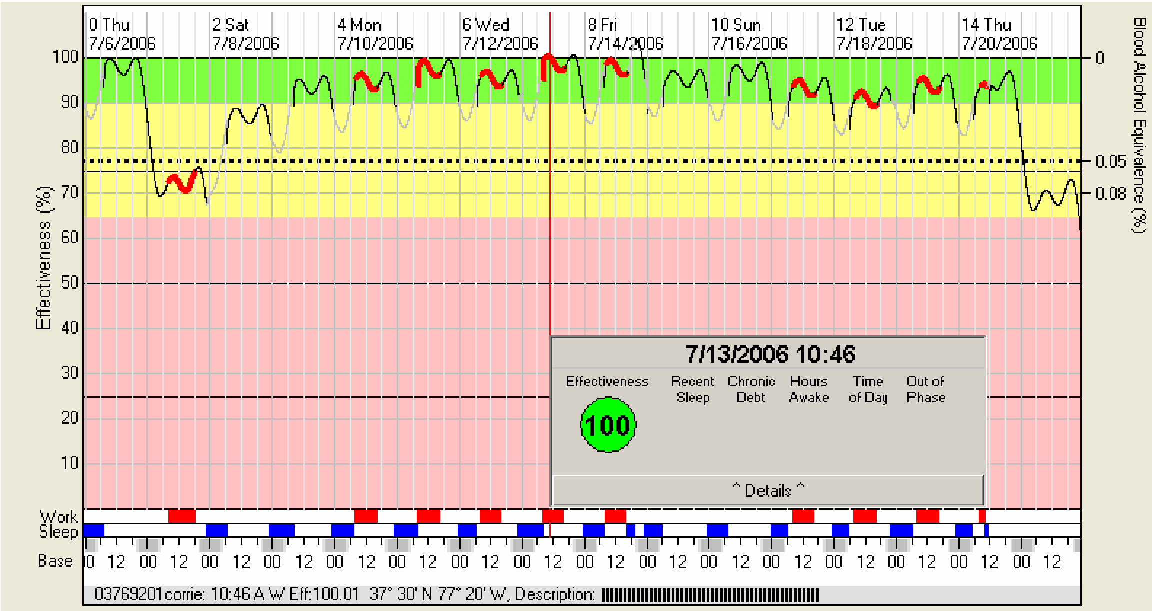

Figure 7. FAST Graphic Output for Officer with Maximum Average Sleep

This participant's mean waking effectiveness (as calculated by the FAST software) is 92.58%, In general, this individual was operating "in the green" for most of the data collection period.

2. FAST Analysis for Median Mean Nightly Sleep

The median squadron member slept an average of approximately 7 hours, 25 minutes nightly (see Figure 8).

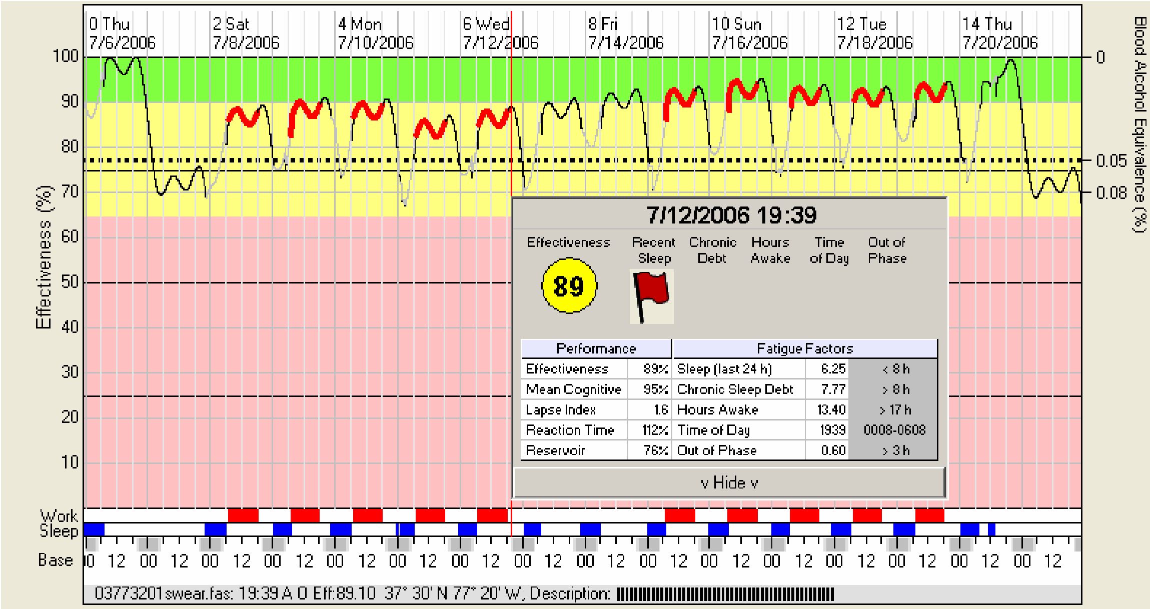

Figure 8. FAST Graphic Output for Median Sleep

Based on the FAST output, this participant's mean waking effectiveness was 87.80%. For most of study period, this participant was operating in high yellow band, with some daily circadian peaks exceeding the 90% level. Using the blood alcohol equivalent scale, this individual's mean waking effectiveness was comparable to a blood alcohol content of slightly under 0.05% (see FAST output, Figure 8).

3. FAST Analysis for Minimum Mean Nightly Sleep

The Officer with the least amount of mean sleep per night was getting approximately 6 hrs, 14 min sleep per night. The FAST plot for this individual is see in Figure 9 below.

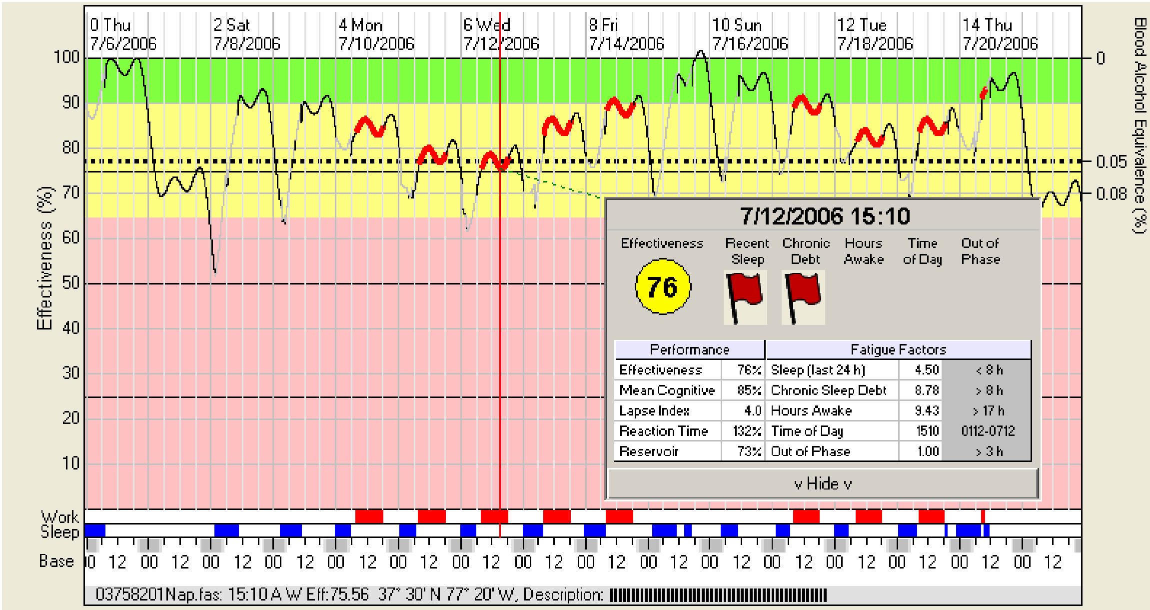

Figure 9. FAST Graphic Output for Officer with Minimum Mean Sleep

The scalloping pattern seen in his data illustrate how he is getting more sleep on weekends. Based on the FAST output, this participant's mean waking effectiveness was 84.01%. For most of study period, this participant was also operating in the high yellow band, with some daily peaks exceeding the 90% level (see FAST output, Figure 9). Due to this individual's chronic sleep debt, however, using the blood alcohol equivalent scale, this individual's mean waking effectiveness was comparable to a blood alcohol content of slightly under 0.08%. While not over the legal BAC limit, this fatigue level indicates a level of impairment unacceptable in a high reliability organization.

The FAST plot for the enlisted participant receiving the least sleep is seen in Figure 10. Discounting the first three days of observation, this enlisted participant's mean effectiveness was 75.01%. The blood alcohol equivalence was just slightly less than 0.10%. These results show that a number of study participants operate in a state of chronic sleep deficiency. It would be potentially dangerous for such individuals to participate in any high reliability operations, including maintenance of aircraft or participating in flight operations.

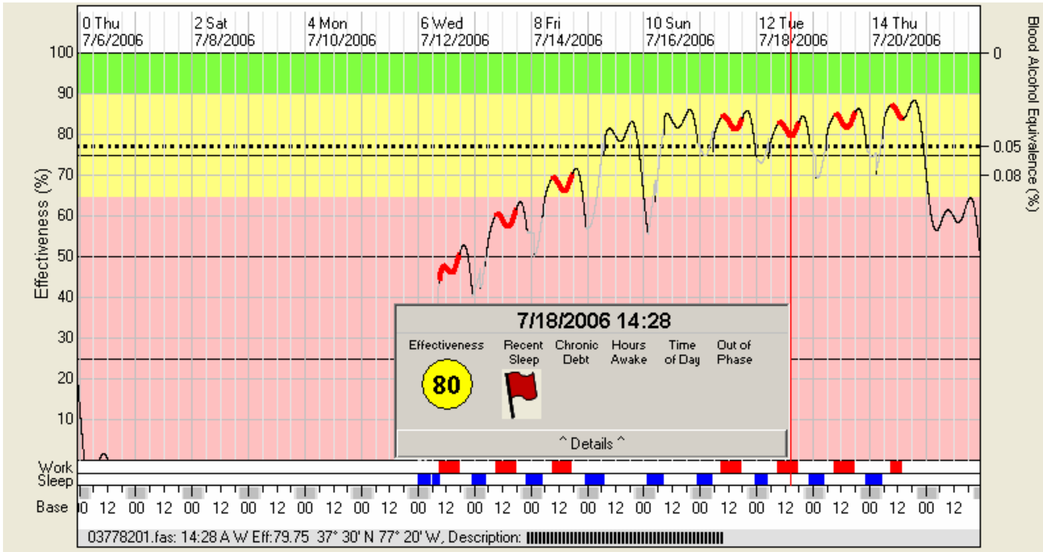

Figure 10. FAST Graphic Output for Enlisted Member with Minimum Mean Sleep

The FAST analyses showed a high level of degradation, as indicated by reduced predicted effectiveness, experienced by study participants. This degradation was especially evident in the enlisted personnel in the study. Daily mean predicted effectiveness of the enlisted participants ranged from 70.04% to 87.48%. The largest sleep differential was observed on Wednesday nights, leading to the 13.45% decrement in predicted effectiveness of enlisted personnel on Thursdays.

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V. DISCUSSION

A. SUMMARY

This study reports the findings of a 14 day cross sectional study undertaken to assess the amount of sleep attained by aviation crew and pilots of a mine hunting helicopter squadron stationed in Norfolk, Virginia. Actigraphy data showed that during the study period, enlisted personnel received significantly less nightly sleep than the officers of the same unit. During the study period, the participants, on average, received less sleep than recommended for their age group. On Mondays, Wednesdays and Fridays, the enlisted population received significantly less sleep than the officers. This sleep differential manifest as a decrement in predicted effectiveness on the following Thursday.

A sleep hygiene education program could benefit the entire squadron. Knowing the signs and dangers of sleep deprivation, as well as using fatigue countermeasures, may assist in both performance and increased safety of operations.

The ability to correlate sleep with data such as officer-enlisted status, years of service, gender, and designator among such a small population was useful; however, the lack of an ability to obtain this information without violating anonymity requirements may have reduced the response rate on all questions and questionnaires. Similarly, some participants removed their actigraphs at scheduled intervals such that a continuous reading throughout the study period was not available for data analysis. A recommendation for future studies is to implement a system that will allow tracking of these items by individual without violating anonymity requirements.

An alternative to paper copy demographic and sleep log surveys should be considered. The paper survey return rate for demographic, sleep apnea and Epworth sleepiness scores was 58.3% of the study population. Sleep log survey response was much higher at 84.5%, suggesting once again that concern for anonymity was a factor.

B. CONCLUSIONS

We did not expect to find such big differences in the amounts of sleep received by officers and enlisted personnel in the study. This difference could have major implications for the quality of work performed by enlisted personnel, especially maintenance-related work. While we saw differences across all the days of the study period, the biggest difference was seen on Wednesday nights. Upon further exploration, this Wednesday night disparity in amount of sleep between officers and enlisted personnel may be attributable to Ladies Night at local bars.

The cumulative effects of fatigue on performance are well established. Significant differences were observed between the average nightly sleep of officer and enlisted personnel. Officers received on average 42 minutes more sleep per night across the entire study period. When accounting for day of the week, the officer and enlisted disparity increases even more on Mondays, Wednesdays and Friday. This analysis showed that the predicted effectiveness (using the Fatigue Avoidance Scheduling Tool) of enlisted members was clearly degraded.

As demonstrated by the relationship between amount of sleep and affective mood of participants, other factors may have contributed to the differences we observed in sleep hours and predicted effectiveness, e.g., working conditions, light exposure levels, type of work performed, health issues, and stress. This study sample is not by intent nor design representative of the entire population of aviators and aircrew of the U.S. Navy. Broad generalizations concerning the entire aviation warfare community should not be made based on the results of this study. However, the fact that a large portion of study participants were functioning under impairment due to a state of chronic sleep deprivation should not be dismissed out of hand.

Although not specifically addressed in this research, it is important to note some possible effects due to chronic sleep deprivation. Other studies have shown that sleep-deprived participants select less-demanding problems and significantly less-demanding tasks. Increased sleepiness, fatigue, and reaction time were associated with the selection of less difficult tasks. Sleep-deprived participants were often unaware of their condition, and did not perceive a reduction in effort (Engle-Friedman et al., 2003). These studies suggest that sleep loss may result in low-effort behavior which runs counter to the requirements of successful military operations. Within the military—and during combat in particular—sleep-deprived people are faced with a myriad of decisions. The selection of the least demanding option in complex situations may negatively affect safety, reliability, and the effective integration of multiple facets of tasks (Hockey et al. 1998). Ultimately, this tendency toward less demanding options may result in serious, perhaps even life-threatening, consequences.

The results of this thesis are consistent with the assertion that there is an urgent need to improve how we address sleep and fatigue of our military personnel. Sleep deprivation and fatigue, particularly in the enlisted personnel, was a problem for the participants in this study and is a major cause for concern. In order to reduce the fatigue resulting from sleep deprivation, it is recommended that the enlisted personnel be encouraged to sleep an additional hour and to adhere to a more regular schedule thus reducing the variations in their sleep/wake cycle. We hope that these findings will serve as a catalyst for others to examine these issues further.

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APPENDICES

APPENDIX A. DEMOGRAPHIC FREQUENCIES AND VALID PERCENTAGES

		Frequency	Percent	Valid Percent
Gender				
	male	20	76.9	90.9
	female	2	7.7	9.1
	Total	22	84.6	100
Marital Status				
	single never married	6	23.1	24
	married	15	57.7	60
	divorced	4	15.4	16
	Total	25	96.2	100
Education				
	high school graduate	4	15.4	16
	attended or attending college	6	23.1	24
	graduated college	12	46.2	48
	graduate school or more	3	11.5	12
	Total	25	96.2	100
Race/Ethnicity				
	Caucasian/European American	24	92.3	96
	Hispanic/Hispanic American	1	3.8	4
	Total	25	96.2	100
NEC/Designator				
	1310	8	30.8	34.8
	1315	7	26.9	30.4
	7886	6	23.1	26.1
	8226	1	3.8	4.3
	8236	1	3.8	4.3
	Total	23	88.5	100
Experience				
	less than 6 months	1	3.8	4
	1-3 years	8	30.8	32
	3-5 years	4	15.4	16
	5-10 years	2	7.7	8
	more than 10 years	10	38.5	40
	Total	25	96.2	100
Smoker				
	moderate smoker	2	7.7	8
	light smoker	1	3.8	4
	social smoker	1	3.8	4
	non smoker	21	80.8	84
	Total	25	96.2	100
Alcohol				
	moderate drinker	1	3.8	4
	light drinker	8	30.8	32
	social drinker	9	34.6	36
	non drinker	7	26.9	28
	Total	25	96.2	100

APPENDIX B. DESCRIPTIVE STATISTICS

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Activity Mean	265	58.35	268.74	142.306	30.83868
Sleep Efficiency	246	6.71	100	89.03817	12.68106
Age in years	20	22	41	30.7	5.813777
Number of children living in household?	21	0	4	1	1.264911
TOTALCAF	21	4.6	425	177.6476	135.9557
TOTALEP	21	0	19	7.142857	5.012841
RISKAPSC	21	4	14	6.809524	2.619524
Valid N (listwise)	16				

APPENDIX C. CORRELATION MATRIX OF DEMOGRAPHIC AND SLEEP AS DEPENDENT VARIABLE BY OFFICER-ENLISTED STATUS

Correlations Between Demographic and Sleep as Dependent Variable

Enlisted (n = 10)

Question		1	2	3	4	5	6	7	8	9	10	11	12	13
Activity Mean	Corr		-0.60	-0.07	-0.25	-0.85	0.61	-0.32	0.18	-0.14	0.00	-0.33	-0.76	-0.52
	Sig.		0.00	0.87	0.55	0.01	0.15	0.44	0.68	0.74	1.00	0.42	0.03	0.19
Sleep Minutes	Corr			-0.26	-0.25	0.55	-0.33	-0.15	-0.79	-0.33	-0.22	0.58	0.59	-0.20
	Sig.			0.53	0.55	0.16	0.46	0.72	0.02	0.42	0.60	0.13	0.12	0.64
Age	Corr				0.58	0.20	-0.18	0.91	0.31	0.52	0.00	0.21	-0.03	0.48
	Sig.				0.13	0.64	0.70	0.00	0.45	0.18	1.00	0.62	0.94	0.23
Marital Status	Corr					0.45	0.11	0.53	0.44	0.41	0.08	-0.26	-0.22	0.60
	Sig.					0.26	0.81	0.18	0.28	0.31	0.84	0.54	0.61	0.12
Education	Corr						-0.51	0.29	-0.27	0.18	-0.07	0.05	0.68	0.39
	Sig.						0.24	0.49	0.52	0.67	0.88	0.90	0.06	0.35
NEC	Corr							-0.05	0.07	0.45	-0.57	-0.55	-0.52	0.19
	Sig.							0.91	0.88	0.31	0.18	0.20	0.24	0.68
Experience	Corr								0.30	0.73	-0.20	0.22	0.22	0.75
	Sig.								0.46	0.04	0.64	0.59	0.61	0.03
# Children in household?	Corr									0.25	0.44	-0.29	-0.42	0.40
	Sig.									0.55	0.28	0.49	0.30	0.33
Total Caffine	Corr										-0.61	-0.38	0.26	0.80
	Sig.										0.11	0.35	0.53	0.02
Epworth Risk	Corr											0.21	-0.32	-0.22
	Sig.											0.61	0.44	0.61
Apnea Risk	Corr												0.19	-0.15
	Sig.												0.65	0.73
Smoker	Corr													0.29
	Sig.													0.48
Drinker	Corr													
	Sig.													

Officer (n = 15)

Question		1	2	3	4	5	6	7	8	9	10	11	12	13
Activity Mean	Corr		-0.51	-0.17	-0.37	-0.03	-0.07	0.24	-0.05	-0.19	-0.10	-0.48	0.22	-0.29
	Sig.		0.00	0.62	0.24	0.93	0.82	0.45	0.89	0.55	0.76	0.11	0.50	0.37
Sleep Minutes	Corr			0.06	0.20	0.17	0.15	0.18	0.29	0.19	-0.40	-0.14	0.22	0.71
	Sig.			0.86	0.54	0.60	0.65	0.59	0.37	0.55	0.19	0.66	0.49	0.01
Age	Corr				0.62	0.55	-0.46	0.81	0.23	0.15	-0.23	0.34	-0.26	0.08
	Sig.				0.03	0.06	0.13	0.00	0.46	0.63	0.47	0.28	0.41	0.80
Marital Status	Corr					0.21	-0.11	0.23	0.15	0.35	-0.29	-0.05	-0.37	0.12
	Sig.					0.49	0.72	0.45	0.63	0.25	0.33	0.88	0.21	0.70
Education	Corr						-0.51	0.28	-0.48	-0.12	-0.20	0.13	-0.53	0.10
	Sig.						0.08	0.36	0.10	0.69	0.52	0.68	0.06	0.74
Designator	Corr							-0.26	0.27	-0.21	-0.10	-0.19	0.27	0.18
	Sig.							0.40	0.37	0.50	0.74	0.53	0.38	0.57
Experience	Corr								0.27	0.07	-0.51	0.10	0.28	0.12
	Sig.								0.38	0.82	0.07	0.75	0.36	0.71
# Children in household	Corr									0.30	0.13	0.08	0.25	0.12
	Sig.									0.33	0.66	0.79	0.40	0.71
Total Caffine	Corr										-0.04	0.17	-0.08	-0.32
	Sig.										0.90	0.58	0.80	0.29
Epworth Risk	Corr											0.55	-0.19	-0.18
	Sig.											0.05	0.52	0.56
Apnea Risk	Corr												-0.04	-0.08
	Sig.												0.90	0.80
Smoker	Corr													0.33
	Sig.													0.27
Drinker	Corr													
	Sig.													

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
Significance is two-tailed

APPENDIX D. ANALYSIS OF VARIANCE OF AFFECTIVE COMPONENTS

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
B2HAPPY	Between Groups	11.984	1	11.984	18.410	.000
	Within Groups	100.241	154	.651		
	Total	112.224	155			
B2TENSE	Between Groups	8.409	1	8.409	9.731	.002
	Within Groups	132.210	153	.864		
	Total	140.619	154			
B2SLEEPY	Between Groups	21.076	1	21.076	24.338	.000
	Within Groups	132.498	153	.866		
	Total	153.574	154			
B2EVENTE	Between Groups	12.405	1	12.405	16.774	.000
	Within Groups	113.144	153	.740		
	Total	125.548	154			
B2IRRITA	Between Groups	3.826	1	3.826	4.288	.040
	Within Groups	136.522	153	.892		
	Total	140.348	154			
B2POORCO	Between Groups	13.329	1	13.329	26.961	.000
	Within Groups	75.639	153	.494		
	Total	88.968	154			
B2TIRED	Between Groups	25.118	1	25.118	23.779	.000
	Within Groups	161.617	153	1.056		
	Total	186.735	154			
B2WORRIE	Between Groups	23.354	1	23.354	28.177	.000
	Within Groups	126.813	153	.829		
	Total	150.168	154			
B2CALM	Between Groups	7.053	1	7.053	9.409	.003
	Within Groups	113.941	152	.750		
	Total	120.994	153			

APPENDIX E. CORRELATION MATRIX OF AFFECTIVE COMPONENTS BY SLEEP MINUTES

Spearman's Rho Correlations Between Affective Components by Officer-enlisted status

Enlisted (n = 10)

Grade			1	2	3	4	5	6	7	8	9	10	11	12
enlist	minutes	Corr		-0.10	0.26	0.15	-0.17	0.19	0.15	0.03	0.15	-0.19	-0.22	-0.31
		Sig	.	0.55	0.12	0.37	0.34	0.26	0.39	0.87	0.40	0.25	0.20	0.07
	happy	Corr			-0.45	-0.22	0.42	-0.46	-0.70	-0.27	-0.72	0.70	0.41	0.52
		Sig		.	0.01	0.20	0.01	0.00	0.00	0.11	0.00	0.00	0.01	0.00
	tense	Corr				0.12	-0.50	0.16	0.40	0.09	0.45	-0.60	-0.32	-0.25
		Sig			.	0.49	0.00	0.34	0.02	0.61	0.01	0.00	0.07	0.14
	sleepy	Corr					-0.34	0.30	0.44	0.54	0.28	-0.22	0.01	-0.39
		Sig				.	0.04	0.08	0.01	0.00	0.10	0.21	0.97	0.02
	even temp	Corr						-0.52	-0.57	-0.27	-0.39	0.61	0.47	0.51
		Sig					.	0.00	0.00	0.10	0.02	0.00	0.01	0.00
	irritable	Corr							0.71	0.12	0.29	-0.55	-0.42	-0.66
		Sig						.	0.00	0.48	0.09	0.00	0.01	0.00
	concentrati	Corr								0.31	0.60	-0.68	-0.46	-0.61
		Sig							.	0.07	0.00	0.00	0.01	0.00
	tired	Corr									0.19	-0.13	-0.08	-0.33
		Sig								.	0.27	0.44	0.66	0.05
	worried	Corr										-0.51	-0.52	-0.39
		Sig									.	0.00	0.00	0.02
	calm	Corr											0.37	0.60
		Sig										.	0.03	0.00
	quality	Corr												0.53
		Sig											.	0.00
	alert	Corr												
		Sig												.

Officer (n = 15)

off	minutes	Corr		0.18	-0.31	-0.10	0.15	-0.24	-0.14	-0.13	-0.19	0.32	-0.13	0.05
		Sig		0.05	0.00	0.32	0.13	0.01	0.15	0.19	0.04	0.00	0.17	0.64
	happy	Corr			-0.75	-0.64	0.54	-0.61	-0.66	-0.60	-0.58	0.63	0.34	0.17
		Sig			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
	tense	Corr				0.61	-0.61	0.73	0.65	0.64	0.74	-0.63	-0.42	-0.23
		Sig				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	sleepy	Corr					-0.40	0.54	0.75	0.71	0.52	-0.41	-0.42	-0.26
		Sig					0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	even temp	Corr						-0.80	-0.42	-0.54	-0.76	0.49	0.35	0.16
		Sig						0.00	0.00	0.00	0.00	0.00	0.00	0.07
	irritable	Corr							0.54	0.68	0.81	-0.55	-0.29	-0.24
		Sig							0.00	0.00	0.00	0.00	0.00	0.01
	concentrati	Corr								0.73	0.55	-0.50	-0.28	-0.18
		Sig								0.00	0.00	0.00	0.00	0.04
	tired	Corr									0.65	-0.41	-0.46	-0.35
		Sig									0.00	0.00	0.00	0.00
	worried	Corr										-0.51	-0.48	-0.27
		Sig										0.00	0.00	0.00
	calm	Corr											0.21	0.14
		Sig											0.02	0.10
	quality	Corr												0.30
		Sig												0.00
	alert	Corr												
		Sig												.

APPENDIX F. FAST OUTPUT DEFINITIONS

Duration	Minutes from start to end of interval
Activity Mean	Mean activity score (counts/epoch)
Activity Median	Median activity score (counts/epoch)
Activity SD	SD of Activity Mean
Wake Minutes	Total minutes scored as Wake
Sleep Minutes (SM)	Total minutes scored as Sleep (Sleep+Light Sleep)
% Sleep	Percent minutes scored Sleep (100*(Sleep+Light Sleep)/Duration)
Light Sleep	Total minutes scored Light Sleep (Sadeh Infant Algorithm)
% Light Sleep	Percent minutes scored Light Sleep (100*Light Sleep/Duration)
Sleep Efficiency	(100* Sleep Minutes/(O-O Duration))
Sleep Latency	Minutes to start of 1st 20-min block with > 19 min sleep
Wk after Slp Onset	Wake min during O-O interval
Acceleration Index	Change in activity rate during interval
Activity Index	% epochs with >0 activity score
Bad Epochs	Total bad epochs
Wake Episodes (WE)	# of blocks of contiguous wake epochs
Mean Wake Episode	Mean duration of WE (minutes)
Long Wake Episodes	WE >= value in Options: Sleep: Sleep Statistics Criteria text box
Longest WE	Duration of longest WE (minutes)
Sleep Episodes (SE)	# of blocks of contiguous sleep epochs
Mean Sleep Episode	Mean duration of SE (minutes)
Long Sleep Episodes	SE >= value in Options: Sleep: Sleep Statistics Criteria text box
Longest SE	Duration of longest SE (minutes)

APPENDIX G. DEMOGRAPHICS SURVEY

Demographic Survey
Instructions: Please circle the most appropriate answer for each question.

Gender:	A. male	B. female
Age in years:	___________	
Marital Status:	A. Single, never married	B. Single, living with a partner
	C. Married	D. Separated
	E. Widowed	F. Divorced
Education level (please circle the highest level completed):	A. Less than high school graduate	B. High school graduate
	C. Attended or attending college	D. Graduated college
	E. Graduate school or more	F. Technical school/Other
Race/ Ethnicity:	A. African/ African American	B. Asian/ Asian American
	C. Caucasian/ European American	D. Hispanic/ Hispanic American
	E. Native American	F. Other (specify):_________

What is your NEC/Designator? ___________________________________

How long have you worked in your occupation:	A. less than 6 months	B. 6 months to 1 year
	C. 1 to 3 years	D. 3 to 5 years
	E. 5 to 10 years	F. more than 10 years
Number of children living in household?	_________________	
Ages of children living in household?	_________________	
I consider myself to be a:	A. Heavy smoker	B. Moderate smoker
	C. Light smoker	D. Social smoker
	E. Non-smoker	

I consider myself to be a:	A. Heavy drinker C. Light drinker E. Non-drinker	B. Moderate drinker D. Social Drinker
Do you take any prescription medications which may cause drowsiness?	A. Yes	B. No

Instructions: Please provide the number of like-products used

On average, how many caffeinated products do you use per day?	#__	8 oz. cola (23 mg of caffeine)
	#__	8 oz. diet cola (31 mg)
	#__	240 mL Red Bull (80 mg)
	#__	8 oz. coffee (110 mg)
	#__	8 oz. decaf coffee (5 mg)
	#__	6 oz. caffe latte (90 mg)
	#__	6 oz. cappuccino (90 mg)
	#__	1 oz. espresso (90 mg)
	#__	1 oz. decaf espresso (10 mg)
	#__	8 oz. instant coffee (90 mg)
	#__	8 oz. imported tea (60 mg)
	#__	8 oz. U.S. tea (40 mg)
	#__	8 oz. iced tea (60 mg)
	#__	1 oz. milk chocolate candy
	#__	Dietary supplement/weight loss products. (Brand)___________________

APPENDIX H. EPWORTH SLEEPINESS SCALE

The Epworth Sleepiness Scale is used to determine the level of daytime sleepiness. Use the following scale to choose the most appropriate number for each situation:

0 = would *never* doze or sleep.
1 = *slight* chance of dozing or sleeping
2 = *moderate* chance of dozing or sleeping
3 = *high* chance of dozing or sleeping

Situation	***Chance of Dozing or Sleeping***
Sitting and reading	____
Watching TV	____
Sitting inactive in a public place	____
Being a passenger in a motor vehicle for an hour or more	____
Lying down in the afternoon	____
Sitting and talking to someone	____
Sitting quietly after lunch (no alcohol)	____
Stopped for a few minutes in traffic while driving	____
Total score (add the scores up) (This is your Epworth score)	____

APPENDIX I. POST EPWORTH SURVEY DEBRIEF

Post Epworth Survey Debrief

A score of 10 or more is considered sleepy. A score of 18 or more is very sleepy. If you score 10 or more on this test, you should consider whether you are obtaining adequate sleep, need to improve your sleep hygiene and/or need to see a sleep specialist. These issues should be discussed with your personal physician.

APPENDIX J. SLEEP APNEA RISK SCREENING

Assess your risk for sleep apnea. The total score for all 5 sections is your *Apnea Risk Score*. Write in your best answer for each question and see where you stand.

A. How frequently do you experience or have you been told about snoring loud enough to disturb the sleep of others?

1. Never
2. Rarely (less than once a week)
3. Occasionally (1 – 3 times a week)
4. Frequently (More than 3 times a week)

Answer_____

B. How often have you been told that you have "pauses" in breathing or stop breathing during sleep?

1. Never
2. Rarely (less than once a week)
3. Occasionally (1 – 3 times a week)
4. Frequently (More than 3 times a week)

Answer_____

C. How much are you overweight?

1. Not at all
2. Slightly (10 – 20 pounds)
3. Moderately (20 – 40 pounds)
4. Severely (More than 40 pounds)

Answer______

D. What is your Epworth Sleepiness Score?

1. Less than 8
2. 9 – 13
3. 14 – 18
4. 19 or greater

Answer ______

E. Does your medical history include:

1. High blood pressure
2. Stroke
3. Heart disease
4. More than 3 awakenings per night (on the average)

5. Excessive fatigue
6. Difficulty concentrating or staying awake during the day

Answer ______

APPENDIX K. POST SLEEP APNEA SCREENING

Post Questionnaire for Sleep Apnea Risk

If you answered 3) or 4) for questions A-D, especially if you have one or more of the conditions listed in question E, then you may be at risk for sleep apnea and should discuss this with your physician.

Note: You should always discuss sleep-related complaints with your physician before deciding on medical evaluation and treatment.

APPENDIX L. PARTICIPANT CONSENT FORM

PARTICIPANT CONSENT FORM

1. **Introduction.** You are invited to participate in a study of the effect of fatigue on psychomotor vigilance and its correlation to aviator performance on minesweeping tasks. With information gathered from you and other participants, we hope to discover insight on fatigue and psychomotor vigilance and demonstrate the feasibility of using said measures as a predictive tool for performance and safety. We ask you to read and sign this form indicating that you agree to be in the study. Please ask any questions you may have before signing.

2. **Background Information.** This information is collected for the purpose of completing thesis requirements for graduate education, Masters of Science, Human Systems integration at The Naval Postgraduate School.

3. **Procedures.** If you agree to participate in this study, the researcher will explain the tasks in detail. There will be two data collection periods: a) baseline development period when performance is measured during 7-day period of “normal” rest and 2) performance measured during 7-day period of simulated minesweeping operations.

4. **Risks and Benefits.** This research involves no risks or discomforts greater then those encountered during normal helicopter squadron operations. The benefits to the participants are gaining a quantifiable and objective predictive measure of performance based on level of fatigue.

5. **Compensation.** No tangible reward will be given. A copy of the results will be available to you at the conclusion of the experiment.

6. **Confidentiality.** The records of this study will be kept confidential. No information will be publicly accessible which could identify you as a participant.

7. **Voluntary Nature of the Study.** If you agree to participate, you are free to withdraw from the study at any time without prejudice. You will be provided a copy of this form for your records.

8. **Points of Contact.** If you have any further questions or comments after the completion of the study, you may contact the research supervisor, Dr. Nita Lewis Miller, (831) 656-2281, nlmiller@nps.edu

9. **Statement of Consent.** I have read the above information. I have asked all questions and have had my questions answered. I agree to participate in this study.

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Participant’s Signature Date

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Researcher’s Signature Date

APPENDIX M. MINIMAL RISK CONSENT STATEMENT

NAVAL POSTGRADUATE SCHOOL, MONTEREY, CA 93943

VOLUNTARY CONSENT TO BE A RESEARCH PARTICIPANT IN: Determination of Fitness for Flight: Efficacy of Psychomotor Vigilance Task (PVT) and Actigraphy

1. I have read, understand and been provided "Information for Participants" that provides the details of the below acknowledgments.

2. I understand that this project involves research. An explanation of the purposes of the research, a description of procedures to be used, identification of experimental procedures, and the extended duration of my participation have been provided to me.

3. I understand that this project does not involve more than minimal risk. I have been informed of any reasonably foreseeable risks or discomforts to me.

4. I have been informed of any benefits to me or to others that may reasonably be expected from the research.

5. I have signed a statement describing the extent to which confidentiality of records identifying me will be maintained.

6. I have been informed of any compensation and/or medical treatments available if injury occurs and is so, what they consist of, or where further information may be obtained.

7. I understand that my participation in this project is voluntary; refusal to participate will involve no penalty or loss of benefits to which I am otherwise entitled. I also understand that I may discontinue participation at any time without penalty or loss of benefits to which I am otherwise entitled.

8. I understand that the individual to contact should I need answers to pertinent questions about the research is Professor Nita Lewis Miller, Principal Investigator, and about my rights as a research participant or concerning a research, related injury is Prof. Lawrence Shattuck, Human Systems Integration Dept. A full and responsive discussion of the elements of this project and my consent has taken place. **NPS Medical Advisor:** LTC Eric Morgan, MC, USA, Commanding Officer, Presidio of Monterey Medical Clinic, (831) 242-7550, eric.morgan@nw.amedd.army.mil

____

Signature of Principal Investigator Date

____

Signature of Volunteer Date

APPENDIX N. PRIVACY ACT STATMENT

NAVAL POSTGRADUATE SCHOOL, MONTEREY, CA 93943

PRIVACY ACT STATEMENT

1. Purpose: Determination of Fitness for Flight: Efficacy of Psychomotor Vigilance Task (PVT) and Actigraphy

2. Use: This data will be used for statistical analysis by the Departments of the Navy and Defense, and other U.S. Government agencies, provided this use is compatible with the purpose for which the information was collected. Use of the information may be granted to legitimate non-government agencies or individuals by the Naval Postgraduate School in accordance with the provisions of the Freedom of Information Act.

3. Disclosure/Confidentiality:

   a. I have been assured that my privacy will be safeguarded. I will be assigned a control or code number which thereafter will be the only identifying entry on any of the research records. The Principal Investigator will maintain the cross-reference between name and control number. It will be decoded only when beneficial to me or if some circumstances, which is not apparent at this time, would make it clear that decoding would enhance the value of the research data. In all cases, the provisions of the Privacy Act Statement will be honored.

   b. I understand that a record of the information contained in this Consent Statement or derived from the experiment described herein will be retained permanently at the Naval Postgraduate School or by higher authority. I voluntarily agree to its disclosure to agencies or individuals indicated in paragraph 3 and I have been informed that failure to agree to such disclosure may negate the purpose for which the experiment was conducted.

   c. I also understand that disclosure of the requested information is voluntary.

____

Name, Grade/Rank (if applicable)
[Please print]

____

Signature of Volunteer Date

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